

# California High-Speed Train Project



## TECHNICAL MEMORANDUM

### CHSTP Planning Stage Electromagnetic Compatibility Program Plan TM 300.02

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Revision	Date	Description
0	15 Aug 11	Initial Release, R0

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California High-Speed Train Project

# Planning Stage EMC Program Plan

Revision 0  
August 15, 2011

prepared by

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## Revision History

Date	Change
July 27, 2010	First Draft
September 22, 2010	Remove notes for next stage tasks
August 15, 2011	Update to reflect 15% design completion. Remove criteria and refer to Design Manual.
December 19, 2011	Update the Executive Summary based on action list from PMO's review of the document.



## Executive Summary

The California High-Speed Train Project (CHSTP) established and is executing an Electromagnetic Compatibility (EMC) Program that:

- Ensures electromagnetic compatibility of California High-Speed Train (CHST) equipment and facilities with themselves, with equipment and facilities of the CHST neighbors, and with passengers, workers, and neighbors of the CHST.
- Guides and coordinates the EMC design, analysis, test, documentation, and certification activities between CHST project management, systems, and sections through all project phases
- Conforms with the EMC-related CHST System Requirements (SRs)
- Complies with applicable regulatory requirements, including EMC requirements in 49CFR 200-299, particularly Parts 236 and 238, for all CHST systems and sections.

The EMC Program consists of two stages:

- Planning Stage, for the Preliminary Engineering 30% design
- Implementation Stage, including Final Engineering 100% design, Construction, Procurement, and System Integration.

EMC work in the Planning Stage includes:

- EMC requirements
- Environmental Impact Report (EIR) EMC/ Electromagnetic Field (EMF) Surveys and Assessment
- EMC Footprint and other EMC technical investigations
- Electromagnetic Interference (EMI) Safety Analysis and EMC design review of Preliminary Engineering 30% designs
- EMC requirements for contractor and equipment supplier Performance Specifications.

EMC work in the Implementation Stage includes:

- Contractor and equipment supplier EMC Plans
- Contractor and equipment supplier EMC design analyses for emissions and immunity, and EMI safety analyses for Final Engineering 100% designs
- System integration EMC, such as system EMI modeling
- EMC qualification tests
- Monitoring and evaluation by project engineers and managers.

This Planning Stage EMC Program Plan (PSEP) document implements the CHST EMC Program for the Planning Stage. The EMC program will:

- Fulfill the EMC Program requirements listed above
- Conform to APTA SS-E-010-98, or equivalent
- Satisfy EMC requirements from the CHST System Requirements, technical memoranda, and other CHSTP sources
- Establish EMC design guidelines and criteria
- Define scope, organization, responsibilities, tasks, deliverables, milestones, safety requirements, safety testing, analysis, feedback, reporting, etc. for the EMC Program.



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# CHST Planning Stage EMC Program Plan

## 1 Introduction

The California High-Speed Rail Authority (Authority) is designing and building the California High-Speed Train Project (CHSTP). The California High-Speed Train (CHST) will serve the major metropolitan centers of the state over dedicated high-speed rail track. The route will be at-grade, in open trenches, in tunnels, and on elevated guideways. CHST will use electrically powered steel-wheel-on-steel-rail trains which will operate at up to 220 mph on a fully grade-separated alignment with no highway or street crossings. The initial 500-mile segment will operate between San Francisco and Anaheim.

The CHSTP must achieve electromagnetic compatibility (EMC) between:

- CHST equipment and facilities
- Equipment and facilities of CHST neighbors
- Passengers, workers, and neighbors of the CHST.

Accordingly, the CHSTP has established an EMC program to achieve EMC. The EMC program:

- Guides and coordinates the EMC design, analysis, test, documentation, and certification activities between all participants through all project phases and stages
- Conforms with the EMC-related CHST System Requirements (SRs)
- Complies with applicable regulatory requirements, including EMC requirements in 49CFR 200-299, particularly Parts 236 and 238, for all CHST systems and sections.

### 1.1 EMC Program Objective

The CHSTP EMC Program objective is to achieve electromagnetic compatibility (EMC) between:

- CHST equipment and facilities
- Equipment and facilities of CHST neighbors
- Passengers, workers, and neighbors of the CHST.

Further, the EMC program must ensure that electromagnetic interference (EMI) does not adversely affect:

- The safety or dependability of the CHST system and service
- The health of passengers, staff, and neighbors
- The safety or dependability of neighboring equipment and facilities.





To meet the EMC Program objective, this PSEP specifies:

- Activities and deliverables at each project stage and phase for the Project Management team, sections, equipment suppliers, construction contractors, and subcontractors.
- Design guidelines, criteria, and methods.
- EMC design requirements to be included in the Performance Specifications for each affected system or piece of equipment.
- EMC design requirements to be included in the Performance Specifications for each affected construction contract.
- EMC analyses and tests to demonstrate compliance with CHSTP EMC requirements.

## 1.2 EMC Program Scope

This PSEP defines participants, activities, and deliverables in the CHSTP EMC Program for the Concept Phase.

The CHSTP EMC Program scope includes:

- Electromagnetic interactions and related design characteristics
- CHST equipment and facilities
- Equipment and facilities of CHST neighbors

CHST equipment and facilities must work with and not interfere with other CHST equipment and facilities and with neighboring equipment and facilities, in the CHST environment.

The CHST EMC design scope includes:

- Design aspects of the CHST equipment and facilities which can electromagnetically interact with themselves, with other CHST equipment and facilities, and with the equipment and facilities of CHST neighbors
- Train control and communications, traction electrification system, rolling stock, and station equipment

Generally, the CHST project cannot change existing neighbor equipment and facilities to resolve EMC issues, unless the project makes a specific agreement with the neighbor.

CHSTP EMC interaction scope includes:

- Design scope equipment and facilities
- Neighboring equipment and facilities
- Electronic devices carried or used by CHST passengers and staff in CHST facilities and trains



Neighboring equipment and facilities include:

- Electronic devices of neighbors and of California public safety, government, utility, and industrial staff
- Commercial, residential, and industrial buildings and the industrial and commercial equipment used by the buildings and their occupants

EMC Program interfaces with other CHSTP elements include:

- System Assurance
  - CHSTP System Safety Program
  - Hazard Management, including hazard analyses
- Performance Specifications

The CHSTP EMC Program scope excludes:

- Equipment, activities, and responsibilities outside the scope of the CHST project
- Systems and facilities and their suppliers that do not and will not interact with CHST project equipment
- Future neighbor equipment

## 1.3 EMC Program Activities

Planning Stage EMC Program activities include the following:

- The PM team must create and maintain an EMC program and a Planning Stage EMC Program Plan (PSEP), and prepare for the Implementation Stage EMCP
- The PM team and section teams must perform the PSEP activities and create the required deliverables
- The section teams must satisfy EIR requirements from California High-Speed Train—Project-Level Environmental Methodologies, Section 3.4, Electromagnetic Fields and Electromagnetic Interference
- The PM team and section teams must track and report on EMC task completion status and EMC issues.

Implementation Stage EMC activities include the following:

- The PM team must create an Implementation Stage EMC Program Plan (ISEP).
- The PM team and section teams must perform the ISEP activities and create the required deliverables.
- Contractors and equipment suppliers must develop EMC Program Plans for their scopes of supply, perform the planned activities, and create the required deliverables.
- Suppliers and contractors must fulfill the EMC requirements in the performance specifications.
- The PM team, section teams, contractors, and equipment suppliers must track and report on EMC task completion status and EMC issues.



## 1.4 Reference Information

<b>Table 1-1</b> <b>CHSTP EMC Program Reference Information</b>		
<b>ID</b>	<b>Issued By</b>	<b>Title</b>
SS-E-10-98	APTA	Standard for the Development of an Electromagnetic Compatibility Program Plan, edited 2-23-04
	AREMA	Manual for Railway Engineering
	AREMA	Communications and Signals Manual of Recommended Practice
CEC	California Building Standards Commission	California Electrical Code
EN 50121-1:2006	CENELEC	Railway applications - Electromagnetic Compatibility, Part 1: General
EN 50121-2:2006	CENELEC	Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world
EN 50121-3-1:2006	CENELEC	Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle
EN 50121-3-2:2006	CENELEC	Railway applications - Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus
EN 50121-4:2006	CENELEC	Railway applications - Electromagnetic Compatibility, Part 4: Emission and immunity of signaling and telecommunications apparatus
EN 50121-5:2006	CENELEC	Railway applications - Electromagnetic compatibility -- Part 5: emission and immunity of fixed power supply installations and apparatus
EN 50155:2007	CENELEC	Railway applications – Electronic equipment used on rolling stock
EN 50238-1:2003	CENELEC	Railway applications - Compatibility between rolling stock and train detection systems
EN 50238-2:2010	CENELEC	Railway applications - Compatibility between rolling stock and train detection systems - Railway applications - Part 2: Compatibility with track circuits
EN 50238-3:2010	CENELEC	Railway applications - Compatibility between rolling stock and train detection systems - Railway applications - Part 3: Compatibility with axle counters
EN 50388:2005	CENELEC	Railway applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability
	California High-Speed Rail Authority (Authority)	Report to the Legislature December 2009
	Authority	Business Plan 2008 — Engineering Elements, 10/23/2008. System Description, Project Delivery, and Capital and O&M Costs, San Francisco and Merced to Anaheim



**Table 1-1  
CHSTP EMC Program Reference Information**

ID	Issued By	Title
GO 95	CPUC	California Public Utilities Commission General Order 95, Overhead Electric Line Construction
GO 131	CPUC	California Public Utilities Commission General Order 131, Rules Relating to the Planning and Construction of Electric Generation, Transmission/Power/Distribution Line Facilities and Substations Located in California.
CPUC d93-11-013	CPUC	California Public Utilities Commission Decision 93-11-013, interim EMF Policy
CPUC d06-01-042	CPUC	California Public Utilities Commission Decision 06-01-042, updated EMF Policy
FCC OET-65	FCC	Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields, FCC Office of Engineering and Technology Bulletin 65, Edition 97-01, August 1997
FCC OET-65c	FCC	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, FCC Office of Engineering and Technology Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01)
FCC Part 15	FCC	Part 15 of Title 47 of the Code of Federal Regulations
UMTA-MA-06-0153-85-11	FTA	Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures
UMTA-MA-06-0153-85-6 (also identified as UMTA-MA-06-0153-87-2)	FTA	Conductive Interference in Rapid Transit Signaling Systems Volume II: Suggested Test Procedures
UMTA-MA-06-0153-85-8	FTA	Inductive Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures
IEEE Std C95.1-2005	IEEE	IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 3 kHz - 300 GHz
IEEE Std C95.6-2002	IEEE	IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 - 3 kHz
IEEE Std 1100-2005	IEEE	Recommended Practice for Powering and Grounding Electronic Equipment
IEEE Std 1143-1994	IEEE	IEEE Guide on Shielding Practice for Low Voltage Cables
IEEE Std 142-2007	IEEE	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE Std 518-1982	IEEE	IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources
IEEE Std 519-1992	IEEE	Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std 525-2007	IEEE	IEEE Guide for the Design and Installation of Cable Systems in Substations
IEEE Std C2 – 2007	IEEE	National Electrical Safety Code



Table 1-1 CHSTP EMC Program Reference Information		
ID	Issued By	Title
	IEEE	Architectural Electromagnetic Shielding Handbook, Leland H. Hemming, IEEE Press, 1992
NFPA 70-2008	NFPA	2008 National Electric Code, NFPA 70, National Fire Protection Association
NFPA 780-2004	NFPA	Standard for the Installation of Lightning Protection Systems
MIL-HDBK-419A	USDOD	Grounding Bonding and Shielding for Electronic Equipment and Facilities (Volume I, Basic Theory, 1987)
	PG&E	Pacific Gas & Electric Company Transmission Line EMF Design Guidelines, May 1994
	SCE	Southern California Edison EMF Design Guidelines For Electrical Facilities, September 2004
CPUC Summary	SDGE	San Diego Gas and Electric, summary of EMF related activities of the CPUC, <a href="http://sdge.com/safety/electric/emf/emfActivities.shtml">http://sdge.com/safety/electric/emf/emfActivities.shtml</a>

Refer to Section 2 for EMC requirement sources.

## 1.5 Acronyms and Abbreviations

Refer to Technical Memorandum (TM) 0.0a, Design Terms and Acronyms for acronyms and abbreviations used by the CHSTP. Table 1-2 lists acronyms and abbreviations specific to the EMCP.

Table 1-2 Acronyms and Abbreviations	
ac	alternating current
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ATC	Automatic Train Control
Authority	California High-Speed Rail Authority
CCTV	Closed circuit television
CDE	California Department of Education
CENELEC	European Committee for Electrotechnical Standardization
CFR	Code of Federal Regulations
CHST	California High-Speed Train
CHSTP	California High-Speed Train Project
COTS	Commercial off-the-shelf
CRT	Cathode Ray Tube
CPUC	California Public Utilities Commission
dc	direct current
EDA	EMC Design Analysis Report
EIR	Environmental Impact Report
EIS	Environmental Impact Statement



**Table 1-2  
Acronyms and Abbreviations**

EMC	Electromagnetic compatibility
EMCP	EMC Program Plan
EME	Electromagnetic emission
EMF	Electromagnetic Field
EMI	Electromagnetic interference
EMU	Electric multiple unit
EN	Euro Norm
ESA	EMI Safety Analysis
FCC	Federal Communications Commission
FMECA	EMI Failure Modes and Effects Criticality Analysis
FRA	Federal Railroad Administration
FTA	Federal Transportation Administration
FTA	Fault Tree Analysis
G	Gauss
GHz	Gigahertz
GO	General Order
hp	Horsepower
HVAC	Heating, ventilation, and air conditioning
Hz	Hertz
IG	Insulated Ground (per IEEE Std 1100); referred to as isolated ground in the NEC
ISEP	Implementation Stage Electromagnetic Compatibility Program Plan
ISM	Industrial, scientific and medical device frequency band
IEEE	Institute of Electrical and Electronic Engineers
kHz	Kilohertz
kV	Kilovolts
kW	Kilowatts
LCD	Liquid Crystal Display
MPE	maximum permissible exposure
mph	miles per hour
NEC	National Electrical Code
NFPA	National Fire Protection Association
OCS	Overhead Contact System
OET	Office of Engineering and Technology
PB	Parsons Brinckerhoff Quade and Douglas or PB Americas, Inc.
PG&E	Pacific Gas & Electric Company
PHA	Preliminary Hazard Analysis
PM	Program Management
PMT	Program Management Team
PSEP	Planning Stage Electromagnetic Compatibility Program Plan
RPA	FRA Rule of Particular Applicability
RF	Radio Frequency
RMS	Root Mean Square
ROW	Right-of-Way
RSQT	Radio Susceptibility Qualification Test
RST	Rolling Stock
SCADA	Supervisory control and data acquisition
SR	System Requirement



**Table 1-2  
Acronyms and Abbreviations**

SRS	Signal reference structure ground
SSPP	System Safety Program Plan
TCC	Train Control and Communication
Tenco	Turner Engineering Corporation
TES	Traction Electrification System
TM	Technical Memorandum
UL	Underwriters Laboratories
UMTA	Urban Mass Transit Administration (now Federal Transit Administration)
UPS	Uninterruptible Power Supply
VA	Volt-amperes
Vac	Volts alternating current
VVVF	Variable Voltage Variable Frequency
WESS	Wayside Energy Storage System

## 1.6 Contents of this Plan

**Section 1:** The Introduction provides the EMC Program organization and the EMC Program's objectives, scope, and activities.

**Section 2:** The EMC Program Requirements section provides the CHSTP EMC Program requirements.

**Section 3:** The Planning Stage EMC Program Activities and Deliverables section describes the activities and deliverables for the present Planning Stage.

**Section 4:** The Implementation Stage EMC Program Activities and Deliverables section describes the activities and deliverables for the upcoming Implementation Stage.



## 2 EMC Program Requirements

### 2.1 CPUC EMC-Related Requirements

Table 2-1 lists California Public Utilities Commission documents that include EMC considerations.

<b>Table 2-1</b> <b>CHSTP EMC Program Requirements</b>				
<b>No.</b>	<b>Source</b>	<b>ID</b>	<b>Title</b>	<b>Applies to</b>
11	CPUC		EMF Design Guidelines for Electrical Facilities, July 21, 2006	TES
12	CPUC	General Order 52	Construction and operation of power and communication lines for the prevention or mitigation of inductive interference	TCC, TES

### 2.2 FRA EMC-Related Requirements

Table 2-2 lists Federal Railroad Administration (FRA) regulations that include EMC considerations.

<b>Table 2-2</b> <b>CHSTP EMC Program Requirements</b>				
<b>No.</b>	<b>Source</b>	<b>ID</b>	<b>Title</b>	<b>Applies to</b>
13	FRA	49CFR 236.8, Appendix C.b.	Rules, Standards, And Instructions Governing The Installation, Inspection, Maintenance, And Repair Of Signal And Train Control Systems, Devices, And Appliances	TCC, RST
14	FRA	49CFR 238.425, 238.225.d	Passenger Equipment Safety Standards	TCC, RST





### 3 Planning Stage EMC Program Activities and Deliverables

Table 3-1 lists Planning Stage EMC Program activities and deliverables for the PM team and Section teams.

<b>Table 3-1</b> <b>Planning Stage EMC Program Activities and Deliverables</b>			
<b>No.</b>	<b>Task</b>	<b>Program Management</b>	<b>Regional Consultant</b>
<b>1</b>	<b>EMC Program</b>		
1.1	Planning Stage EMC Program Plan	Develop the project-wide PSEP.	Review the PSEP.
1.2	EMC Program Management	Track EMC Program completion, provide status reports.	
<b>2</b>	<b>EMC Requirements</b>		
2.1	System Requirements	Develop the EMC System Requirements for FRA RPA.	
2.2	Electromagnetic Design Criteria	Develop the EMC design criteria for systems.	Apply the EMC Requirements in Section designs.
<b>3</b>	<b>Environmental Impact Assessment of Electromagnetic Interference and Electromagnetic Fields</b>		
3.1	EIR EMI/EMF Assessment	Develop the system-wide EMC Footprint procedure.  Develop the system-wide EMC Footprint report.	Develop the Section measurement procedure. Measure EMI and EMF environment. Provide report. Assess potentially sensitive receivers along planned route.
<b>4</b>	<b>EMC Technical Investigations</b>		
4.1	EMC Technical Investigation List	Update the PSEP as required.	
4.2	Airport EMC coordination	Ensure proper coordination with airports near the planned CHST route	
4.3	Emission and Susceptibility Limits Standards	Develop EMC standards for COTS and purpose-designed CHSTP equipment	
4.4	Human Exposure Limits for EME	Establish human exposure limits for EME	
4.5	Detailed EMC Design Criteria	Develop detailed EMC design criteria, as required	
4.6	EMC Criteria for Cell Phones	Develop EMC criteria for cell phone base stations and antennas in stations	



<b>Table 3-1</b> <b>Planning Stage EMC Program Activities and Deliverables</b>			
<b>No.</b>	<b>Task</b>	<b>Program Management</b>	<b>Regional Consultant</b>
4.7	Radio Frequency Band List	Develop a list of radio frequency bands in use at and near CHST.	Develop a list of radio frequency bands in use at CHST public service agencies with corridor jurisdiction and activities.
4.8	EMC Coordination with Shared Corridor Railroads	Coordinate EMC activities with shared corridor railroads.	
5	<b>30% EMC Design Assessment</b>		
5.1	EMI Safety Analysis	Perform EMI Safety Analysis for system design.	
5.2	EMC Design Review	Review EMC design for systems and Sections.	
5.3	EMC Design Report	Develop the EMC Design Report for systems and Sections.	
6	<b>EMC Requirements for Bidders</b>		
6.1	Design Manual	Develop EMC Specs project-wide Design Manual	Review the Design Manual.
6.2	Performance Specifications	Develop EMC Bid Specs for Contractors and Suppliers.	Review the Bid Specs.

### 3.1 Planning Stage EMC Program

#### 3.1.1 Planning Stage EMC Program Plan

This Planning Stage EMC Program Plan (PSEP) provides the CHSTP EMC Program objectives, scope, requirements, organization, schedule, activities, and deliverables.

Regional consultants are required to review the PSEP and implement the EMC requirements.

#### 3.1.2 EMC Program Management

The PMT will provide EMC Program guidance for system and Section designers, track the EMC Program status, and provide the EMC Program status reports.



## **3.2 EMC Requirements**

### **3.2.1 System Requirements**

The PMT developed System Requirements (SRs) for the FRA Rule of Particular Applicability (RPA) task, per TM 0.9, “Process to Support Development of a CHSTP Draft Rule of Particular Applicability.” The PMT consolidated EMC requirements from all applicable sources into System Requirements documentation.

The performance specifications and design manual incorporate the SR EMC requirements.

### **3.2.2 Electromagnetic Design Criteria**

The PMT is establishing service-proven and industry-accepted design guidelines, criteria, techniques, and methods to ensure that the CHST facilities and equipment achieve the EMC requirement. The CHST equipment and facilities shall be electromagnetically compatible with one another, with other CHST equipment and facilities, and with the equipment and facilities of CHST's neighbors.

The CHSTP Design Manual Chapter 26 provides EMC design criteria for the CHST equipment and facilities. The EMC design criteria cover all CHST systems and related facilities:

- Communications
- Train Control System
- Traction Electrification System
- Rolling Stock
- Station and Facility Equipment

The EMC design criteria include:

- Cable
- Grounding
- Equipment
- Facility Power and Traction Power
- Motors and Controllers
- Equipment Rooms and Location
- Emission and Immunity Limits
- FCC Type-Accepted Radio Equipment
- Human Exposure



Table 3-2 is an overview of CHST EMC design criteria.

<b>Table 3-2</b> <b>EMC Design Criteria Overview</b>	
<b>Item</b>	<b>Design Criteria</b>
Cable	Cables shall be designed with proper shielding, shield grounding, entry protection, and termination. Each cable may only be grouped with others with similar signal type and energy level, and each cable or group shall be segregated appropriately from other cable groups. Cable runs shall be placed in conduit, raceway, or duct as needed to provide segregation and prevent magnetic or electric coupling from high-energy sources. Use fiber optic cable where practical for EMC. Power cables shall be treated according to required practice for their voltage class.
Grounding	Grounding shall conform to the listed standards, provide a suitable safety ground, and signal reference structure ground connections. Long adjacent fences and pipelines shall be regularly grounded or if not grounded, divided into insulated sections to prevent electric shock.
Equipment	Equipment designs shall control emissions and enhance immunity. Design considerations shall include placement, enclosures, filters, modulation methods, interconnect design, and component characteristics.
Facility Power	AC power for equipment shall be properly taken from separate feeder and branch circuits, isolated, regulated, backed up, and protected as required. AC power for remote trackside locations can be taken from the negative feeder by a dedicated transformer and disconnect. High-current power supply ac cables shall be run twisted together, in metal conduit where possible, to minimize magnetic coupling. Traction power cables shall be run with the smallest feasible separation of supply feed and return cables. Layout shall minimize the loop area of high current cables. Utility power distribution lines shall be routed and carried to system facilities following applicable electromagnetic interference / electromagnetic field (EMI/EMF) regulations and guidelines.
Motors and Controllers	Motor starter or inverters shall be provided with suitable protection and line and load filtering to minimize transients and surges at start and stop. Wiring shall be by twisted and/or shielded cables in conduit as appropriate.
Equipment Rooms and Location	Within physical constraints of planned facilities, equipment shall be located so that high power sources are physically separated as far as practical from most vulnerable susceptible equipment. Shielding shall be provided as needed.
Emission and Immunity Limits	Equipment shall be designed and tested to conform to the selected emission and immunity limits. Commercial off the shelf (COTS) equipment shall meet the specified standards. Custom equipment shall meet the selected standards, which are FCC Part 15, EN 50121-4, and applicable standards. In cooperation with the adjacent railroad, mitigate coupling of system 60 Hz power into track circuits of adjacent railroads. Coordinate with the operator of any airport adjacent to the alignment to ensure EMC.
FCC Type-Accepted Radio Equipment	Radio equipment shall be FCC type-approved. Frequencies for licensed radio equipment shall be coordinated within the system and with other California users. Equipment that transmits or receives on a specific frequency shall be coordinated with the established list of frequencies used by other equipment. Industrial, scientific and medical device frequency band (ISM) equipment shall be FCC type-accepted ISM band equipment, e.g., 2.4 or 5.8 GHz. ISM design applications shall operate adequately with interference from other ISM band users.
Human Exposure	Placement of radio transmit antennas shall not result in human exposure to fields above limits. Traction electrification facilities shall be posted with signs alerting staff with pacemakers of potentially hazardous EMF levels.

Refer to the CHSTP Design Manual Chapter 26 for detailed EMC design criteria for the CHST systems and equipment.



### 3.3 Environmental Impact Assessment of Electromagnetic Interference and Electromagnetic Fields

CHSTP Regional Consultants need EMC information to prepare the CHSTP Environmental Impact Report/Impact Statement (EIR/EIS). For environmental-specific EMC information, the Regional Consultant Teams must perform radiated electric and magnetic field measurements for each Section. The PM team created a “Measurement Procedure for Assessment of CHSTP Alignment EMI Footprint” (MPE) to guide the Regional Consultants so they can make consistent measurements and identify potentially sensitive equipment and/or medical or research activities that may be affected by CHST EMI or electromagnetic field (EMF) emissions.

The process consists of several tasks:

Task 1 - Collect Section EMC data. Steps are:

- Task 1.1: The CHST Project Management Team (PMT) developed the EMC survey procedure (MPE).
- Task 1.2: Each Regional Consultant develops a region-specific EMI Footprint Measurement Procedure (S-MPE). Select the Section EMI measurement sites.
- Task 1.3: Each Regional Consultant performs the Section EMI measurements. Establish the baseline electromagnetic ambient and identify worst-case wayside emitters and susceptibility victims. Provide a report.

Task 2 - Determine the areas of EMC influence in each Section. Steps are:

- Task 2.1: The PMT uses the Section survey data, performs analysis, and develops the project-wide CHSTP EMC footprint, including expected emission impact vs. distance from track centerline, vs. frequency.
- Task 2.2: Each Regional Consultant applies the ‘footprint’ to Section alignments to assess the potential impact of the CHSTP EMC footprint on neighbors and develops the Section EMC Impact Assessment Reports.

### 3.4 EMC Technical Investigations

EMC issues may require technical investigation during the Planning Stage. The PM team will:

- Develop a technical investigations list
- Perform the EMC technical investigations
- Prepare reports with specific implementation recommendations. The purpose of the EMC Technical Investigation Report is to provide direct input for the performance specifications.



EMC Technical Investigations may include tasks to:

- Ensure proper coordination with airports near the planned CHST route.
- Set emission and susceptibility limits standard for commercial off the shelf equipment (COTS) and for equipment designed for the CHST project.
- Determine limits for electromagnetic emissions (EME), for human exposure to RF fields
- Establish detailed design criteria for cable shielding; equipment shielding; architectural shielding; conduit, raceway, duct shielding; and for cable segregation.
- Determine EMC criteria for data and voice radio for CHST systems and operations, for public safety radio equipment included within CHST facilities, and for cell phone base stations and antennas in stations and along the CHST corridor.
- Determine appropriate application of National Electric Code, National Electric Safety Code, AREMA C&S, and CHST-specific provisions.
- Collect radio frequencies in use at and near the CHST, include applicable public safety agencies with which CHST must directly communicate.
- Coordinate EMC activities with shared corridor railroads such as Caltrain, Metrolink, BNSF, and UPRR.

### **3.5 30% EMC Design Assessment**

#### **3.5.1 30% EMI Safety Analysis**

The PMT will perform an EMI Safety Analysis (ESA) for the preliminary engineering 30% design, including:

- Preliminary Hazard Analysis (PHA)
- Fault Tree Analysis (FTA)
- EMC Critical Items List

The EMC Critical Items List will guide safety-related EMC activities in the implementation stage.

The ESA will:

- Document protective actions which prevent a hazard occurrence.
- Demonstrate that the equipment and its actions are adequate to prevent an EMI hazard.
- Distinguish between
  - EMI-affecting failures which are automatically protected
  - Those which are annunciated for operator or maintainer action
  - Those which are unannunciated failures.



### **3.5.2 30% EMC Design Review**

The PMT will perform a review of the 30% EMC Design. Design review objectives are:

- Provide feedback on the 30% system and facility design drawings and Performance Specifications.
- Identify changes needed to incorporate EMC requirements.
- Evaluate design-specific mitigations against electromagnetic interference.

### **3.5.3 30% EMC Design Report**

The PMT will develop a 30% EMC Design Report, combining results of the EMI Safety Analysis and EMC Design Review for system and Section designs. The report will include summary results from EMC technical investigations.

## **3.6 EMC Requirements for Contractors**

### **3.6.1 EMC Requirements for Performance Specifications**

The PMT is establishing EMC requirements and EMC design provisions for inclusion in the Systems Performance Specifications for all system and relevant construction procurements. The Performance Specification EMC Requirements will include requirements for each affected supplier and contractor to:

- Develop, deliver, and follow an EMC Plan
- Use and document appropriate EMC design guidelines, criteria, and methods in its equipment and construction
- Perform required EMC analysis and reporting
- Perform required EMC testing

The Performance Specifications will apply the EMC design criteria from the Design Manual Chapter 24. The criteria are summarized in section 3.2.2.

The EMC design provisions will consider conducted and radiated emissions, conducted and radiated immunity, surge and impulse, etc.



## 4 Implementation Stage EMC Program Activities and Deliverables

The Performance Specifications will require each system supplier to perform and report on EMC qualification tests to demonstrate that the supplied equipment conforms to the applicable CHSTP EMC requirements.

Table 4-1 provides a preliminary list of Implementation Stage EMC tasks and deliverables. The ISEP will provide an updated list of tasks and deliverables.

Table 4-1 Implementation Stage EMC Program Activities and Deliverables					
No.	Task	Project Management Team	Regional Consultant	Contractor	Equipment Supplier
<b>1</b>	<b>EMC Planning</b>				
1.1	Implementation Stage EMC Plan (ISEP)	Develop the ISEP	Review and accept the ISEP	Review and accept the ISEP	Review and accept the ISEP
1.2	Contractor and Equipment Supplier EMC Plan	Approve the Contractor and Supplier EMC Plans.	Review the Contractor and Supplier EMC Plans.	Develop an EMC Plan per the ISEP requirements.	Develop an EMC Plan per the ISEP requirements.
<b>2</b>	<b>EMC Design Analysis</b>				
2.1	Emissions Analysis	Approve the Emissions Analyses.	Review the Emissions Analyses.	Perform the Emissions Analysis.	Perform the Emissions Analysis.
2.2	Immunity Analysis	Approve the Immunity Analyses.	Review the Immunity Analyses.	Perform the Immunity Analysis.	Perform the Immunity Analysis.
2.3	Design Report	Approve the Design Report.	Review the Design Report.	Perform the Design Report.	Perform the Design Report.
<b>3</b>	<b>EMI Safety Analysis</b>				
	EMI Safety Analysis	Approve the EMI Safety Analyses.	Review the EMI Safety Analyses.	Perform the EMI Safety Analysis.	Perform the EMI Safety Analysis.
<b>4</b>	<b>EMC Qualification Test Planning</b>				
4.1	Project-wide System Integration EMC Qualification Test Plan	Develop the Project EMC Qual Test Plan.	Review the Project EMC Qual Test Plan.		
4.2	Contractor and Supplier EMC Qualification Test Plan	Approve the EMC Qual Test Plans.	Review the EMC Qual Test Plans.	Develop the EMC Qual Test Plan.	Develop the EMC Qual Test Plan.
4.3	EMC Qualification Test Procedures	Approve the EMC Qual Test Procedures.	Review the EMC Qual Test Procedures.	Develop the EMC Qual Test Procedures.	Develop the EMC Qual Test Procedures.
<b>5</b>	<b>EMC Qualification Tests</b>				





<b>Table 4-1</b> <b>Implementation Stage EMC Program Activities and Deliverables</b>					
No.	Task	Project Management Team	Regional Consultant	Contractor	Equipment Supplier
5.1	Emission and Susceptibility Limit	Approve Emission & Susceptibility Qual Tests.	Review Emission & Susceptibility Qual Tests.	Perform Emission & Susceptibility Qual Test for all equipment units.	Perform Emission & Susceptibility Qual Test for all equipment units.
5.2	ATC System Immunity	Approve ATC Immunity Qual Tests.	Review ATC Immunity Qual Tests.	Perform ATC Immunity Qual Test, as directed.	Perform ATC Immunity Qual Test.
5.3	Emission Affecting ATC System	Approve Emission Affecting ATC Qual Tests.	Review Emission Affecting ATC Qual Tests.	Perform Emission Affecting ATC Qual Test, as directed.	Perform Emission Affecting ATC Qual Test.
5.4	Radio Susceptibility	Approve Radio Susceptibility Qual Tests.	Review Radio Susceptibility Qual Tests.	Perform Radio Susceptibility Qual Tests, as directed.	Perform Radio Susceptibility Qual Tests.
5.5	Human Exposure to EMF	Approve EMF Qual Tests.	Review EMF Qual Tests.	Perform EMF Qual Tests, as directed.	Perform EMF Qual Tests.

## 4.1 Implementation Stage Detailed Design EMC Planning

### 4.1.1 EMC Program Plan Update

The PM team will develop an Implementation Stage EMC Plan (ISEP) to specify:

- Implementation Stage EMC program participants
- Requirements
- Design guidelines, criteria, and methods
- Schedule
- Activities and deliverables of the Project Management Team, Section teams, construction contractors, and system equipment suppliers

The ISEP will address potential EMC issues during construction, including from high power equipment and temporary communications, power, grounding, and other equipment.

### 4.1.2 Contractor and Supplier EMC Plans

Per requirements of the ISEP and Performance Specifications, construction contractors and system equipment suppliers will develop an EMC Plan for its scope of supply. Each Contractor and Supplier EMC Plan must address potential EMC issues during construction, including from high power equipment and temporary communications, power, grounding, and other equipment. The Contractor shall execute and certify completion of all Implementation Stage tasks, including resolution of EMC interfaces with all neighbors including adjacent railroads and airports.



## 4.2 EMC Design Analysis

The ISEP and Performance Specifications will require each system supplier to provide an EMC Design Analysis Report (EDA) which shows that the equipment to be supplied conforms with and satisfies all applicable CHSTP EMC design requirements. The EDA will include Emissions Analysis and Immunity Analysis.

### 4.2.1 Emissions Analysis

Each equipment supplier will develop an Emissions Analysis for each equipment item or system with a peak power rating greater than 10 kW.

### 4.2.2 Immunity Analysis

Each equipment supplier will develop an Immunity Analysis for each equipment item or system with electrical or electronic equipment which could be affected by other electrical equipment.

## 4.3 EMI Safety Analysis

The ISEP and Performance Specifications will require each system supplier to provide an EMI Safety Analysis (ESA) for its equipment.

The objective of the ESA is to demonstrate that the CHSTP and its systems:

- Provide adequate protection against hazards due to EMI
- Are safe under normal conditions
- Detect, annunciate, and respond to failures, preventing EMI from increasing beyond acceptable levels
- Resolves all potential EMC hazards involving neighbors, including adjacent railroads and airports.

The CHSTP safety design goals are:

- No single point failure can cause an unacceptable hazard.
- No unannunciated failure can combine with a later failure to cause an unacceptable hazard.
- No unacceptable hazard can result if maintenance is performed as required and the equipment is operated in the specified environment.

The ESA will include at least these elements:

- EMI Preliminary Hazard Analysis (PHA)
- EMI Fault Tree Analysis (FTA)
- EMI Failure Modes and Effects Criticality Analysis (FMECA) or other system hazard analysis
- ESA Report.



## **4.4 EMC Qualification Test Planning**

### **4.4.1 Project-wide System Integration EMC Qualification Test Plan**

The PMT will develop a Project-wide System Integration EMC Qualification Test Plan. Equipment suppliers will support the Project-wide System Integration EMC Qualification Test per the Bid Specification requirements. The EMC Qualification Tests will be tracked for completion under the CHST Verification and Validation program.

### **4.4.2 Contractor and Supplier EMC Qualification Test Plan**

The ISEP and Performance Specifications will require the supplier of each item subject to an EMC qualification test requirement to:

- Submit a test procedure to the CHSTP engineer for review and approval.
- Perform the test per the test procedure and the applicable CHSTP Bid Specification requirement.
- Submit a test report for approval.

## **4.5 Emission and Susceptibility Limit Qualification Tests**

All equipment units, regardless of supplier, must conform to CHSTP-specified standard emissions and susceptibility limits. The Performance Specifications will require each individual equipment item in the design scope to be tested by its system supplier and demonstrated to conform to the applicable limits. Equipment suppliers will:

- Submit a test procedure to the CHSTP engineer for review and approval.
- Perform the test per the test procedure and the applicable CHSTP Bid Specification requirement.
- Submit a test report for approval.

## **4.6 Automatic Train Control System Qualification Tests**

### **4.6.1 ATC System Immunity**

The Automatic Train Control (ATC) system supplier must document and demonstrate the immunity levels of the ATC system, and particularly of its track circuits with respect to rolling stock conducted and inductive interference.



#### **4.6.2 Emissions Affecting ATC System**

For equipment that can potentially interfere with the CHSTP ATC system:

- Performance Specifications will require the rolling stock supplier and suppliers of other significant emitters, if any, to perform a set of EMC tests.
- Tests will demonstrate compatibility with the CHSTP requirements for rolling stock conducted, inductive, and radiated interference, with an important focus on emissions which can affect ATC track circuit equipment.

#### **4.7 Radio Susceptibility Qualification Test**

The Performance Specifications will require appropriate equipment in the design scope to be tested in a Radio Susceptibility Qualification Test (RSQT). The RSQT will:

- Subject the selected electrical and electronic equipment to radiated emissions from a selected set of radios and cellular telephones in use at and around the CHST.
- Subject CHST radio communication equipment to tests to ensure that its functions are not disturbed by the normal or abnormal operation of CHST equipment and trains, by the normal interactions with neighbor radio communications, equipment, and utilities, or by jamming signals of defined level and location.
- Monitor the integrity of the equipment functions during the test, with the equipment in all applicable operating modes.
- Monitor the integrity of equipment functions in maintenance mode, such as when normally closed equipment enclosures are opened for inspection.

#### **4.8 Electromagnetic Emissions Tests**

The Performance Specifications will require each supplier of radio transmitter equipment to perform a set of tests to demonstrate that the resulting electromagnetic emissions (EME) comply with the CHSTP limits for human exposure to EME.

